Hybrid Navigation Systems for Advanced Air Mobility

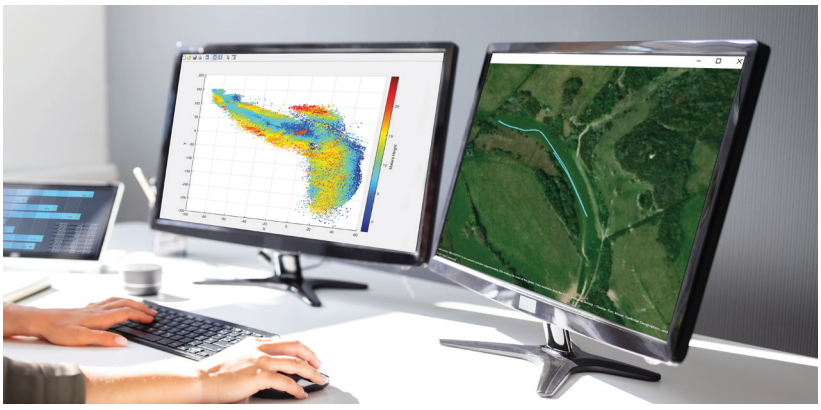
Enhancing urban and regional transportation by enabling autonomous aircraft to take off, navigate, and land in complex environments at aviation levels of safety using automotive sensors.

Aircraft operations in urban areas must increase beyond current capacity if the economic growth potential resulting from an advanced air mobility (AAM) infrastructure is to be realised. This requires precision navigation in dense traffic in complex environments, such as inner cities, which are difficult to predict. This makes automated systems key enablers of AAM-driven economic growth.

To create an autonomous flight control system for safe operations in such complex, urban environments, CGI and Continental Engineering Services (CES) studied the feasibility of a situationally aware, hybrid navigation solution. The system is based on ASIL (Automotive Safety Integrity Level)-compliant automotive sensor technology, which are integrated with other sensors, passive ranging of 5G networks and GNSS (Global Navigation Satellite System) receivers.

Perception

Situational awareness for an aircraft can be enabled by leveraging mature, ASIL-compliant sensors developed for automotive autonomy. A drone equipped with Continental's ARS540 premium, long-range 4D imaging radar was flown in an open area in the south of England. The figure below shows a plot of the trial area with an elevation scale. One interesting feature is the red (high elevation) mark in the centre of the data, corresponding to a powerline.



Hybrid Navigation

A hybrid approach must be at the heart of any navigation system able to meet the safety and security requirements for advanced air mobility. By fusing the outputs of multiple sensor types, the weaknesses inherent in one can be mitigated by the strengths of another, resulting in a more accurate and reliable system.

Sensors for AAM may include:

- Cameras
- RADAR
- LIDAR
- Inertial Sensors
- GNSS receivers
- Active or Passive 5G ranging

CGI would like to thank the UK Space Agency (UKSA) and the European Space Agency (ESA) for their financial support of the 5G localisation trials.

> "NATS has seen continuous, significant growth of UAV Non Standard Flight (NSF) applications throughout 2021, with the monthly average 51% higher than in 2020. [...] It is predicted that this growth will continue in 2022, supporting the market forecasts that UAV numbers are increasing in the UK."
>
> UK's leading provider of air traffic control services

Localisation

CGI designed algorithms to determine the position of a drone with associated confidence levels for a combined GNSS/5G system. Real-world trials were based on flights of a drone equipped with 5G and GNSS antennas and a self-contained bespoke GNSS and 5G data capture payload, shown here.

The trials confirmed the feasibility of the hybrid approach, as well as giving insights into 5G visibility at altitude.

Summary

Complex systems that need to make critical decisions with high levels of autonomy and minimal human intervention require a very high level of perception of their surrounding environment.

Results demonstrate that a hybrid navigation solution based on publicly available networks and automotive sensors designed for autonomous driving is technically feasible and economically desirable.

Roadmap

CGI and CES have laid out a roadmap for development starting with the current data capture and assessment phase and followed by a series of Minimum Viable Products (MVPs).

Each MVP aims to increase the complexity of the operating environment (from fully controlled spaces to real urban areas) as well as the capabilities of the aircraft (from basic obstacle avoidance through to fully autonomous operations including emergency landing support) and the fidelity of onboard sensor equipment (for example, by using machine learning to improve inertial sensor performance).

For more information, please contact CGI or refer to our white paper, Enabling Autonomous Take-off and Landing in Urban Environments.

About CES

Since 2006, Continental Engineering Services (CES) has been active worldwide as an independently operating provider of comprehensive engineering services with currently more than 2,500 employees across 16 locations worldwide. CES has development teams throughout Europe, America, and Asia, including Frankfurt, Germany, Burgess Hill, UK and Lichfield, UK. With a mature camera and radar portfolio already in series production in automotive and off-highway applications, CES delivers functionality such as object detection, scene mapping and collision avoidance.

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About CGI

Insights you can act on

Founded in 1976, CGI is among the largest IT and business consulting services firms in the world. We are an IT Systems Integrator working to advise, build and operate bespoke, technically complex, mission-critical information systems. Bringing innovation to our clients using proven and emerging technologies, agile delivery processes and our expertise across space, defence, intelligence, aerospace and maritime, all underpinned by our end-to-end cyber capability.

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